continue investigations into the relation of cultural practices to bean beetle injury and control for several seasons.

REFERENCES

1. BAILEY, L. H. The Principles of Vegetable Gardening. New York, Macmillan Co., 1901.
2. SEVEY, G. C. Bean Culture. New York, Orange Judd Co., 1914.
3. THOMPSON, H. C. Vegetable Crops. New York, McGraw-Hill Book Co., 1923.
4. GILLIS, M. C. The Relation Between Rate of Planting and Yield in Garden Beans. Proc. Am. Soc. Hort. Sci. 25: 80–86. 1929.
5. GILLIS, M. C. Bean Yields Again Increased by Thicker Planting. Ill. Agr. Exp. Sta. Ann. Rept. 1928–29. pp. 240–241, 1929.
6. HOWARD, N. F., and ENGLISH, L. L. Studies of the Mexican Bean Beetle in the Southwest, U. S. Dept. Agric. Bul. 1243, 1924.

INSECTICIDES FOR THE CONTROL OF THE MEXICAN BEAN BEETLE

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ABSTRACT

Field tests over a period of three years indicate that potassium hexafluoaluminate and synthetic cryolite are satisfactory for the control of the Mexican bean beetle (*Epilachna corrupta* Muls.) when used as sprays at the rate of 3 pounds to 50 gallons of water. Barium fluosilicate (80 per cent) must be used at the rate of 5 pounds to 50 gallons of water to give satisfactory control, and is considered too expensive to be recommended. These compounds have not given satisfactory control when used as dusts. There appears to be no advantage in changing current recommendations for the use of magnesium arsenate except that the dosage should be increased from 1 pound to 2 pounds to 50 gallons of water where the infestation is heavy. If fluorine compounds are used, the problem of poisonous residues on green beans is not avoided, and green beans should not be sprayed with any of the above compounds after the pods have set.

The problem of the control of the Mexican bean beetle (*Epilachna corrupta* Muls.) by the use of insecticides has been extensively investigated since the discovery of that insect in the eastern part of the United States in 1920. At the outset it was necessary to find an insecticide which would kill the insect but would not injure the tender foliage of the bean plant. Effort was rewarded in the discovery that magnesium arsenate fulfilled the requirements, but that material is not useful as a general insecticide, and is, therefore, not widely distributed, owing to the fact that it is not in demand in large quantities and for general use.

Since the advent of fluorine compounds[1] many hundreds of tests have

[1]Marcovitch, S., Bul. 131, Tenn. Agr. Exp. Sta. 1924.

been conducted. The first fluorine compounds recommended, namely sodium fluosilicate and so-called calcium fluosilicate compound, were not entirely satisfactory. The former injured bean foliage under certain conditions and the latter was lacking in toxicity. Promising results, however, were obtained with other compounds.[2] Later, synthetic cryolite and barium fluosilicate became commercially available and potassium hexafluoaluminate became a commercial possibility. These compounds have been tested for three years and the present status of the investigations is here reported. Also, much progress has been made in the preparation of derris extract, pyrethrum extract, and rotenone, and tests with these compounds are reported.

Fluorine is poisonous to animals and human beings and compounds containing this element must be considered in the same class as those containing arsenic.

During the investigations reported here, many hundreds of applications of various compounds have been made but space will permit only a few general conclusions. Fifty experiments, involving 1,697 plots and over 5,000 applications, were performed during the three seasons.

The work has been conducted at Athens and Columbus, Ohio, and at Norfolk, Va., the work at the latter place being carried on cooperatively with the Virginia Truck Experiment Station. Yield records referred to were obtained at Norfolk, Va., usually under very light or no infestations of the Mexican bean beetle.

Usually a period of three years is sufficient for judging rather definitely the worth of an insect-control measure, but the years 1930, 1931, and 1932 were not normal years. The growing seasons were dry and hot, especially during 1930. The summaries presented here are rather in the nature of progress reports than final conclusions. The trials of rotenone dust cover only two seasons on a few plots, and those with derris extract cover only one season's results on a few plots.

CRYOLITE—SYNTHETIC. The use of this commercial product resulted in increased yields in the great majority of the experiments and appears to be beneficial to the bean plant. At Norfolk it gave excellent results at both 1 pound to 50 and 2 pounds to 50 gallons of water, under conditions of light or medium infestation. It is apparently compatible with Bordeaux mixture.

In Ohio under conditions of heavier infestation only fair control was obtained at 1 pound to 50 gallons and it was not so effective as magnesium arsenate at 1 pound to 50 gallons. At 2 pounds to 50 gallons of

[2]Marcovitch, S., Buls. 134, 140, Tenn. Agr. Exp. Sta. 1926, 1929.
Howard, N. F., Jr. Ec. Ent. Vol. 21, pp. 178–182, Feb. 1928.

water it gave the same degree of control as magnesium arsenate used at the same rate, in most instances, but not so good control under conditions of very heavy infestation. When the dosage was increased to 3 pounds to 50 gallons, control was improved and slightly better results were sometimes obtained than with magnesium arsenate at 2 pounds to 50 gallons, but no better under conditions of very heavy infestation. Increasing the dosage to 4 pounds to 50 gallons did not improve the control.

The material is not very satisfactory for use as a dust and it does not give very satisfactory control undiluted or diluted with equal parts of infusorial earth or lime, but is considerably superior to 80 per cent barium fluosilicate. Its use as a dust is not recommended at present.

In some of the experiments the material did not protect the foliage as long as magnesium arsenate, and it is possible that it may not prove so satisfactory during wet seasons. Each of the three years during which this work was carried on was a relatively dry year and the infestations of the bean beetle where the work was carried on were not so heavy as some which have been experienced in the past.

At present prices there would be no advantage in substituting this material for magnesium arsenate, but it is apparently less injurious to bean foliage. Should its use as an insecticide and its distribution become general, it may prove to be a welcome substitute for magnesium arsenate.

The fluorine compounds may improve as more experience is gained in their manufacture. Their use does not mitigate the danger of poisonous residues on edible truck crops, and when they are used it is not recommended that green beans be sprayed after the pods have set.

POTASSIUM HEXAFLUOALUMINATE. At Norfolk, Va., potassium hexafluoaluminate gave excellent control at 2 pounds and 1 pound to 50 gallons of water. Increased yields were obtained in the majority of instances even when the bean beetle was not a factor in the experiments.

In Ohio it was found that 1 pound to 50 gallons of water was insufficient to afford good control. When used at 2 pounds to 50 gallons it gave about the same degree of control as cryolite and magnesium arsenate at the same rates. At 3 pounds to 50 gallons of water it was slightly superior to cryolite at the same rate and to magnesium arsenate at 2 pounds to 50 gallons. Increasing the dosage to 4 pounds to 50 gallons did not improve control.

As in the case of cryolite, while this material may be substituted for magnesium arsenate, there seems to be no advantage in changing the recommendation at this time.

The material used had poor dusting qualities.

BARIUM FLUOSILICATE (80 Per Cent). At Norfolk, Va., this commercial product gave good results at 1 pound and 2 pounds to 50 gallons of water and very good results at 4 pounds to 50. The increase in yields was greater in some experiments than the reduction in yields in others, and the material is not considered injurious to the bean plant.

In Ohio almost no control was obtained in many instances when the material was used at 1 pound and at 2 pounds to 50 gallons of water. Even at 3 pounds and 4 pounds to 50 gallons of water unsatisfactory control was obtained and it was inferior to cryolite and magnesium arsenate at 2 to 50. At 5 pounds to 50 gallons of water it rendered about the same degree of control as cryolite and potassium hexafluoaluminate at 3 pounds to 50 gallons, and as magnesium arsenate at the latter rate.

Used as a dust, undiluted or diluted with infusorial earth or lime, very unsatisfactory control was obtained and almost no control in some cases when used with equal parts of a carrier.

Visible foliage injury has been noted in a few instances when used at 4 pounds to 50 gallons, but in no case has it proved serious.

At present costs and in view of the heavy dosage required, it is not recommended for the control of the Mexican bean beetle.

BARIUM FLUOSILICATE (98 Per Cent). At Norfolk, Va., increased yields resulted in the majority of the experiments when 98 per cent barium fluosilicate was used, even though insects were not a factor. No appreciable difference in results between this material and the 80 per cent material could be noted when they were used as sprays, although slightly better results were obtained by both. Control was unsatisfactory at 1 and 2 pounds to 50 gallons.

It has poor dusting qualities.

MAGNESIUM ARSENATE. During 1932 magnesium arsenate at 1 pound to 50 gallons of water gave good control in most instances but only fair results at other times. Increased yields resulted in the majority of the experiments. When the dosage was increased to 2 pounds to 50 gallons, better control was obtained but still it did not come up to the standard of former years. Chemical analyses gave no indication of an explanation.

Under conditions of very heavy infestation there have been indications that this arsenical protects the foliage for a longer period of time than do the fluorine compounds, and that 2 pounds of this material is equal to 3 pounds of cryolite or potassium hexafluoaluminate or 5 pounds of 80 per cent barium fluosilicate. Up to 1932 this material

gave as good or better results at 1 pound to 50 gallons as the fluorine compounds at twice the dosage.

Under certain conditions foliage injury may result from its use but at no time has this been serious, and it is usually unnoticed.

This material is not very satisfactory for use as a dust. In fact, there is no effective dust at a reasonable cost which does not injure bean foliage in the Eastern States.

With present knowledge, it is deemed advisable to continue recommendations of the use of this material at 1 pound to 50 gallons except in cases of heavy, infestation, when the dosage should be increased to 2 pounds to 50 gallons.

CALCIUM ARSENATE. Calcium arsenate has not been recommended without reservation by the Bureau of Entomology for use in the Eastern States for several years, owing to the variability of results obtained with different brands as to its injuriousness to the bean plant. A rather intensive study indicated no chemical means of determining how a given sample would affect a bean plant, and no specifications could be made which would avoid injury. The material is effective against the beetle both as a spray and as a dust.

Certain brands may be used as dusts when diluted with 7 parts of hydrated lime, or with 1 part of dusting sulphur and 4 parts of lime. As mentioned below, monohydrated copper-calcium arsenate-lime dusts are also cautiously recommended.

BORDEAUX MIXTURE. Bordeaux mixture (4–6–50) as a rule causes reductions in yields when used alone or in combination with arsenicals or fluorine compounds, in the absence of insect pests, especially when used on lima beans. However, plant injury from calcium arsenate is usually reduced, especially when a weaker mixture (2–6–50 or 3–6–50) is used. Unless protection is desired against leaf hoppers or plant diseases, its use is not unqualifiedly recommended. In combination with calcium arsenate or magnesium arsenate, excellent control of the bean beetle is obtained. The grade of calcium arsenate used is one of the determining factors in plant injury. Visible foliage injury, while sometimes apparently severe, is often outgrown without deleterious effects.

DERRIS EXTRACT. A commercial extract of derris root, containing 5 grams of rotenone per 100 cc. and other extractives, gave satisfactory control at Norfolk, Va., under conditions of light to medium infestation, when used at dilutions of 1 to 250, 1 to 500, 1 to 800, and 1 to 1,000.

Under conditions of medium to heavy infestation in Ohio during 1932, at 1 to 250 and 1 to 400 it gave results equal to or better than magnesium arsenate at 2 pounds to 50 gallons and cryolite at 2 pounds

to 50 gallons of water, and better than a well-known pyrethrum extract at 1 to 400. Only one season's results are available, and further trials should be made before it can be recommended.

It appears to be superior to pyrethrum extract and equal to a combination of the two.

It also appears to be far superior to pure rotenone.

High cost is a prohibitive factor, but since it is probably relatively harmless to man and animals it should be valuable for use, when necessary, on high-priced crops, after pods have set.

STICKERS. On a relatively short-lived plant like the bean the value of the addition of stickers is doubtful. No improvement in control was noted when casein-lime mixture or potash fish-oil soap was used with magnesium arsenate and with the fluorine compounds.

MONOHYDRATED COPPER-CALCIUM ARSENATE-LIME. The use of monohydrated copper-calcium arsenate-lime dust, both 15–15–70 and 20–20–60, resulted in reduced yields in the majority of instances, in the absence of insect pests. It is used in some localities quite extensively and with probably as good results as any dust mixture which is recommended, but the quality of control obtained is far inferior to that obtained with sprays. When well mixed and when it contains a grade of calcium arsenate which is not very injurious to bean foliage, it is probably as satisfactory as any dust which is commercially produced and widely distributed.

ROTENONE DUST. In 1932 a commercial dust containing 0.275 per cent of rotenone gave fair results. Its price at present probably makes this mixture too expensive for general use. As mentioned above, dusting has not proved satisfactory in the Eastern States and dusts are not recommended for good control. However, they are much used because of the ease and speed of application.

In 1931 a commercial dust containing 0.15 per cent of rotenone was ineffective.

PYRETHRUM DUSTS. A commercial dust comprising ground flowers and an inert material, as well as one comprising an inert material impregnated with pyrethrum extract, gave poor results. The impregnated dust gave poorer results than the ground flowers.

DR. T. J. HEADLEE: I have heard during the meetings that tests were put on this summer with magnesium arsenate which resulted very unsatisfactorily, the performance of the magnesium this year not being anywhere equal as in the previous years.

DR. HOWARD: The discussion of magnesium arsenate happened to

be left out. That was true. We have not been able to explain it. The chemical analysis made by the Bureau of Chemistry would not indicate any reason for that experience. However, by increasing the dosage, the material gave control about equal to the other materials used.

DR. FRIEND: I might add in our experiments on the Mexican bean beetle we have been using three pounds of magnesium arsenate instead of two, but did not notice any definite increase in the results obtained. We obtained better results with the magnesium arsenate spray than with any other insecticides. There may be some local differences in the beans or whatever it is, aside from the magnesium arsenate itself.

DR. HOWARD: You used magnesium, three pounds in fifty gallons. I believe in that concentration it is equal or superior to any materials we have tested. Our recommendation in the past has been one pound to fifty gallons.

REPORT ON THE CONTROL OF THE HARLEQUIN BUG, *MURGANTIA HISTRIONICA* HAHN, WITH NOTES ON THE SEVERITY OF AN OUTBREAK OF THIS INSECT IN 1932

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ABSTRACT

The severe outbreak of the Harlequin bug, *Murgantia histrionica* Hahn, during the summer of 1932 in the Norfolk truck crop area was due in part to the mild winter of 1931–32 and to the abundance of preferred host plants in abandoned fields and in seed kale fields. The best control of this pest was obtained with sprays in which rotenone was the active ingredient in combination with a one per cent soap solution. In general, nicotine, Pyrethrum, and oil emulsion sprays were not effective for use against this insect, except at very strong concentrations.

Swallows were observed feeding on the adult insects. The egg parasite, *Ooencyrtus johnsoni* (How.), was found to parasitize from 35 to 55 per cent of all the Harlequin bug eggs collected during August and September.

The mild winter of 1931–32 and the fact that a large number of fields containing cruciferous crops were either abandoned or left standing for seed furnished ideal conditions for the development of a very large population of Harlequin bugs in the vicinity of Norfolk, Va. However, trouble began about the middle of August when dry weather and the feeding of large numbers of these insects, largely second, third and fourth instar nymphs, caused the host plants to dry up and die. The nymphs began migrating out of these fields in search of new food, like